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GOODYEAR AEROSPACE

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AKRON 15, OHIO

MICROELECTRONICS EVALUATION

INTERIM REPORT NO. 8

SERVO LOOP ELECTRONICS

GER-12189S7 20 December 1966

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SECTION I. INTRODUCTION

Goodyear Aerospace is performing various tasks for the National Aeronautics and Space Administration under Contract NAS 8-20205. A complete servo loop electronics system has been assembled and satisfactorily demonstrated to personnel of the George C. Marshall Space Flight Center (MSFC).

SECTION II. ASSEMBLED SERVO LOOP ELECTRONICS

A. GENERAL

Goodyear Aerospace Corporation has constructed a breadboard version of a stabilized platform servo electronics system to demonstrate the compatibility of the modularly constructed segments of the system. The breadboard version was successfully demonstrated in closed-loop operation to MSFC personnel at Huntsville, Alabama.

The problems encountered and results that were obtained when the system was operated in an open-loop configuration are discussed in the following paragraphs. The loop is modularized as shown in Figure 1. Brief descriptions of each modularly constructed section are included in the appendix to this report.

B. OPEN-LOOP PERFORMANCE OF SERVO ELECTRONICS

After the servo electronics were assembled into a working system, the noise on the output was minimized for the system. The transfer characteristic of input a-c voltage to output current is shown in Figure 2. The non-linearity of this characteristic is generated by the pulse width modulator and power driver circuit. The transfer function of input a-c voltage to active filter output as measured with the loop assembled is linear, as shown in Figure 3. The noise observed on the power drive output appeared to be low frequency in nature (approximately 60 Hz).

On initial assembly of the loop, all ground leads were brought to a common ground terminal. Although this connection did not produce an oscillatory condition, it did produce very noisy operation. The noise was reduced to a lower level by decoupling the plus and minus 15-volt supplies to the preamplifier demodulator and the active filter. Decoupling the filter output to the preamplifier demodulator through a series R shunt C network also reduced the noise level.

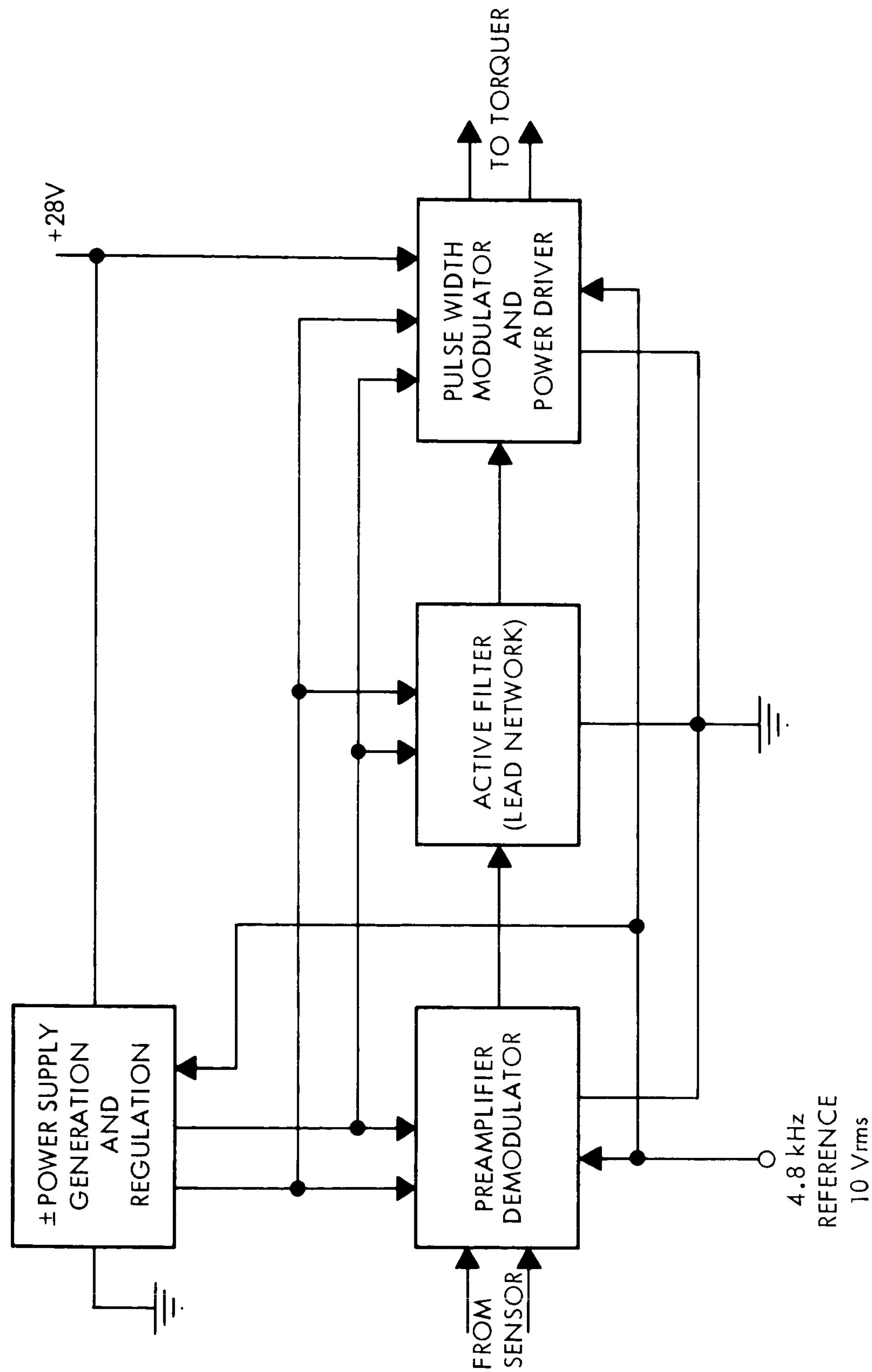


Figure 1. Block Diagram of Servo Electronics Breadboard

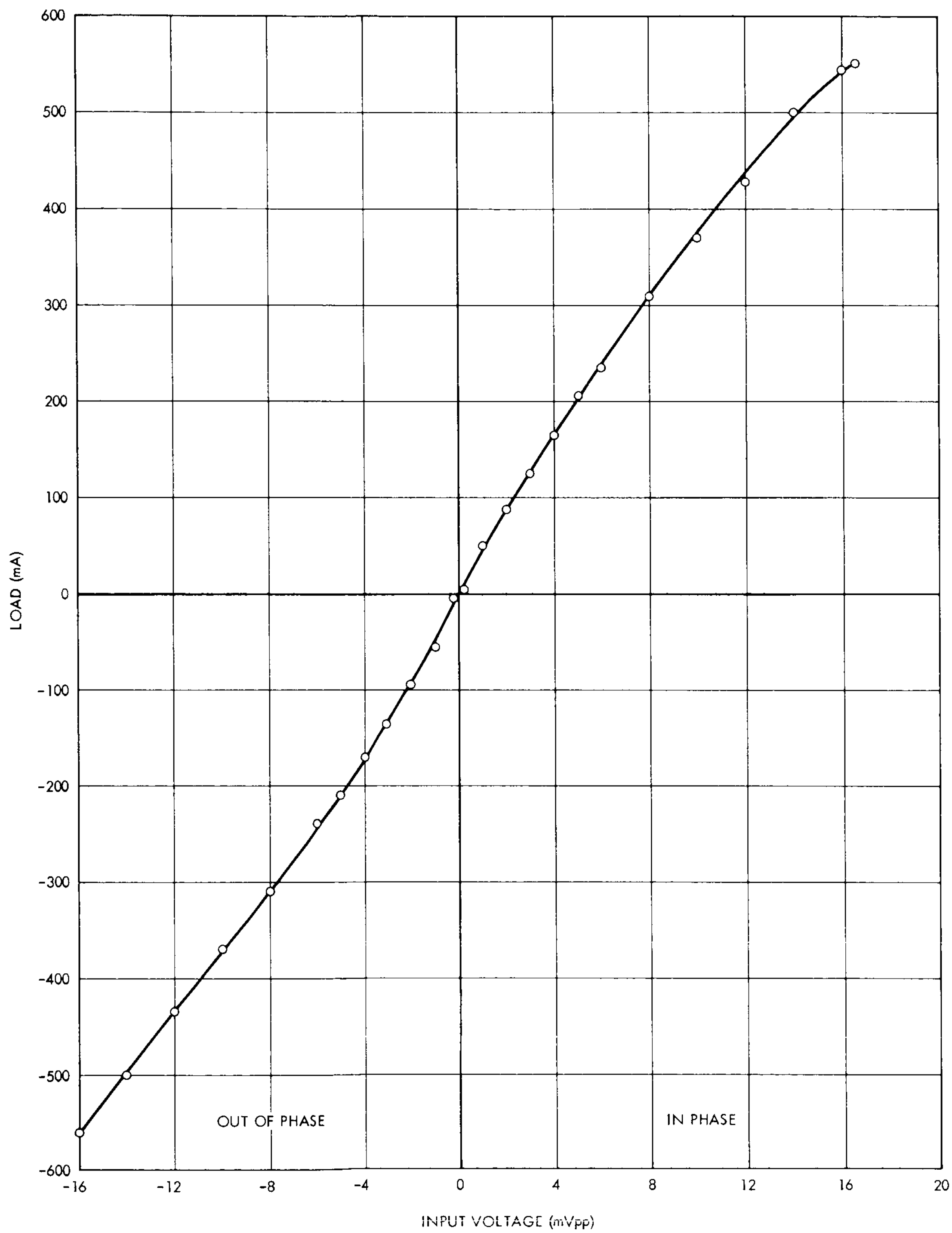


Figure 2. Open Loop Transfer Function

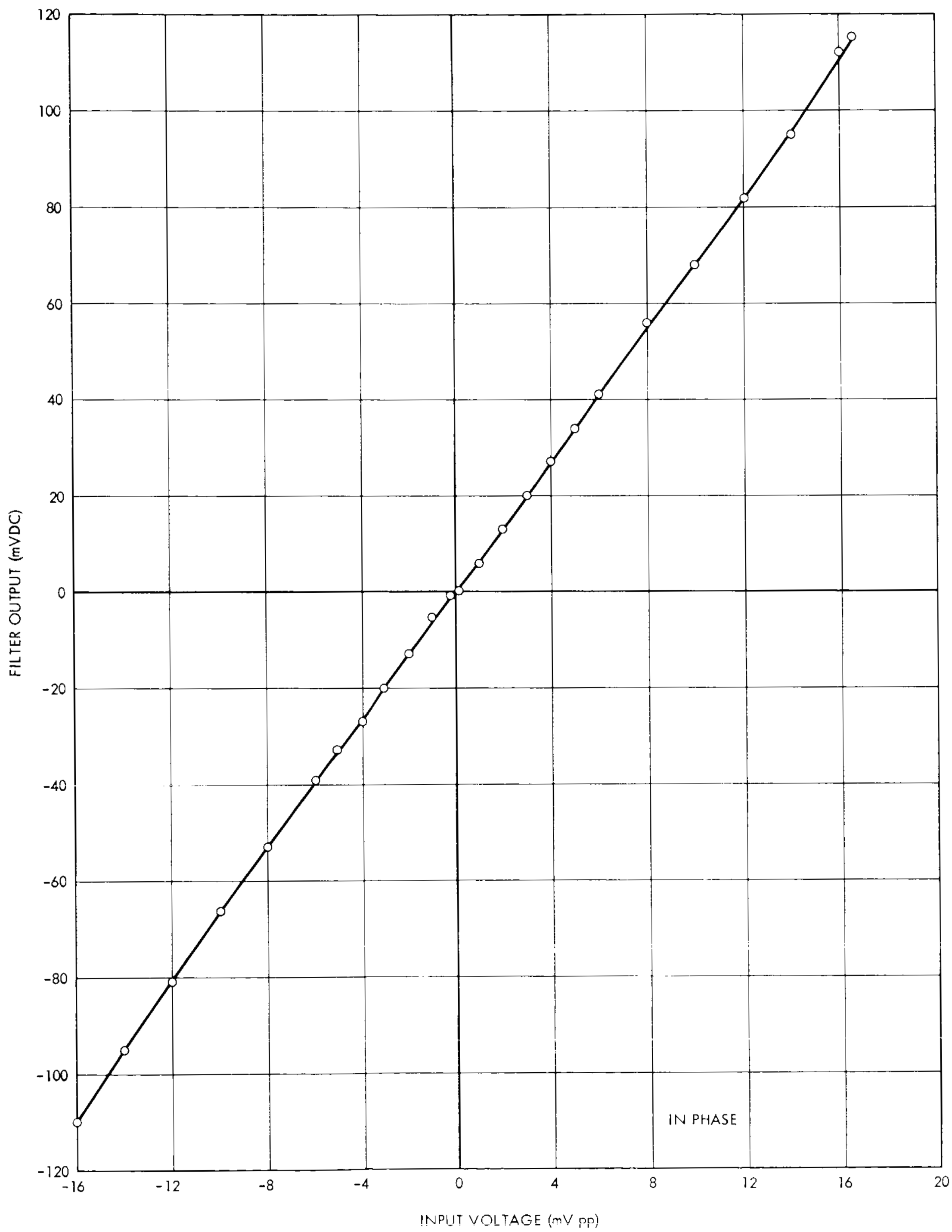


Figure 3. Preamplifier Demodulator - Active Filter Transfer Function

A second ground connection scheme was created by a combination of emperical and theoretical techniques in which the input reference was returned to the ground of the unit providing the signal. A block diagram of this power distribution scheme is shown in Figure 4. This grounding scheme for power distribution gave the quietest loop performance obtained at Goodyear Aerospace. When the power distribution system shown in Figure 4 was used, decoupling of the ±15-volt supplies to the preamplifier demodulator and the active filter had an insignificant effect, so this decoupling was eliminated. Also, the RC coupling network between the active filter and the pulse width modulator no longer made a significant difference, so it was removed.

The total assembled loop was demonstrated to MSFC personnel at the Astrionics Laboratory in Huntsville, Alabama in closed loop operation using an accelerometer provided there. The electronics appeared to function satisfactorily in closed loop operation, and appeared to be operating at a reasonable noise level. The loop was stable, with a loop gain in excess of 30 000 g-cm/degree. The increased gain indicates that trimming the value of the active filter components could provide more damping of the transient response.

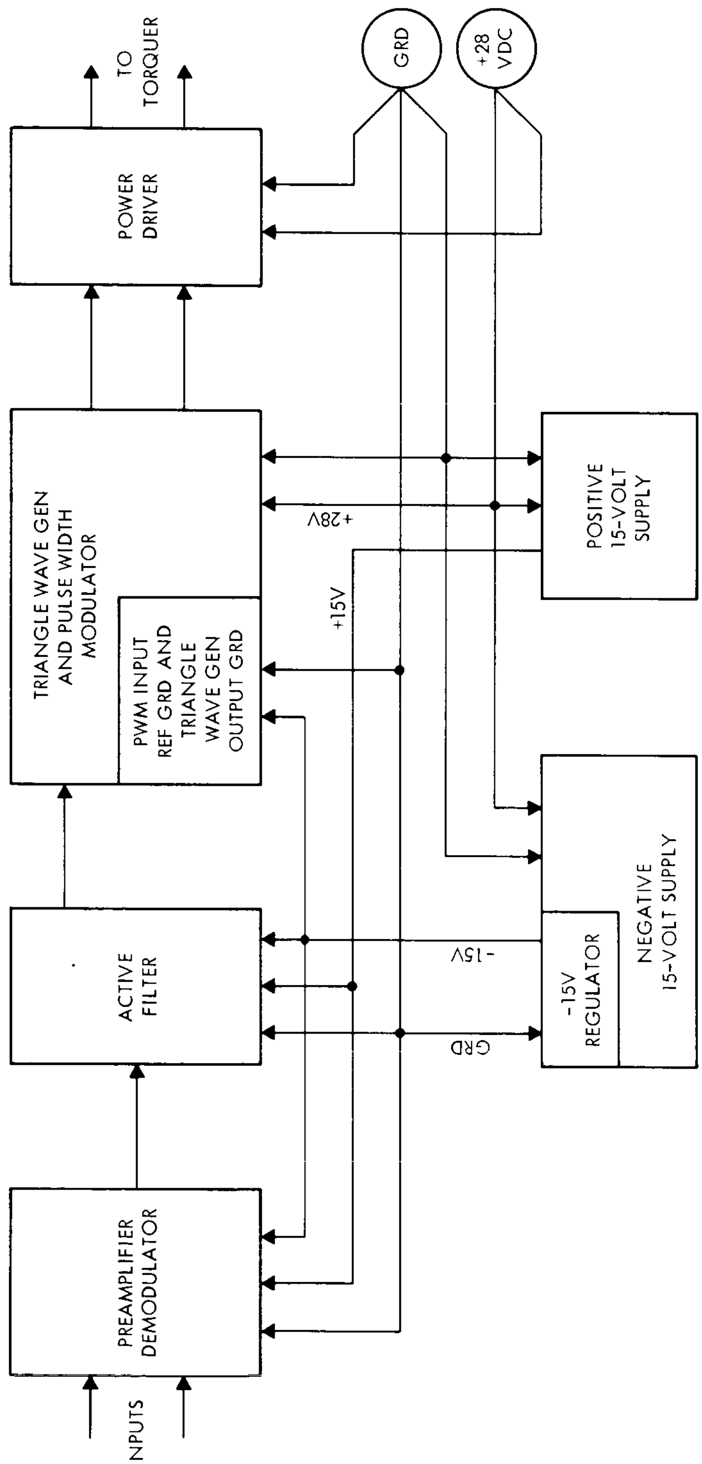


Figure 4. Power Distribution

APPENDIX
MODULE DESCRIPTIONS

A. PREAMPLIFIER DEMODULATOR

The preamplifier demodulator receives the amplitude-modulated, single sideband, suppressed carrier input signal. It amplifies this signal and demodulates it into a phase-sensitive d-c signal, whose amplitude is dependent on the input carrier amplitude. A schematic of the unit is shown in Figure A-1. The voltage transfer characteristics for the device are shown in Figure A-2. For a detailed description of the device, refer to the final report prepared on contract NAS 8-11912, GER 12579 dated 26 January 1966.

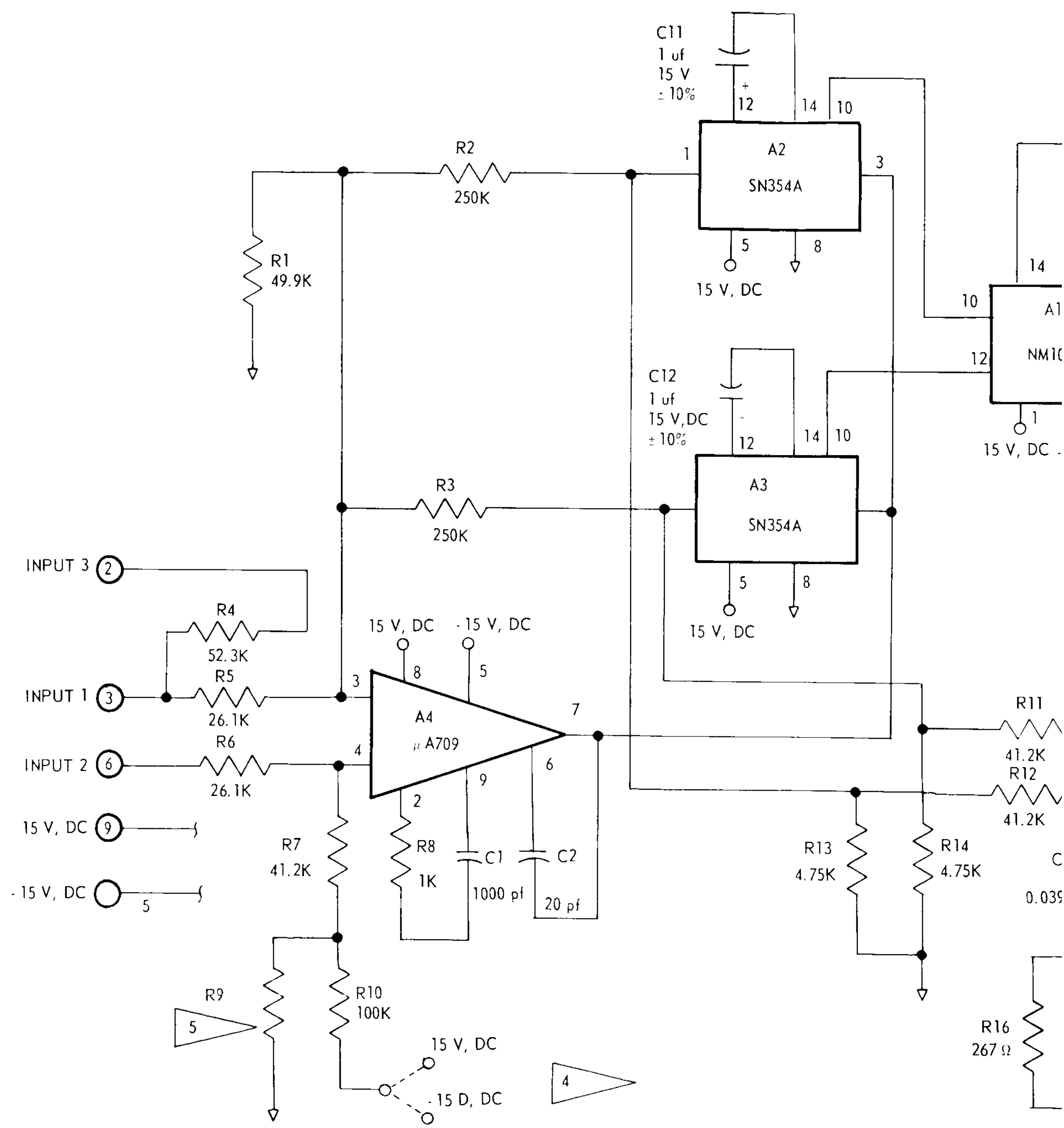
B. ACTIVE FILTER (LEAD NETWORK)

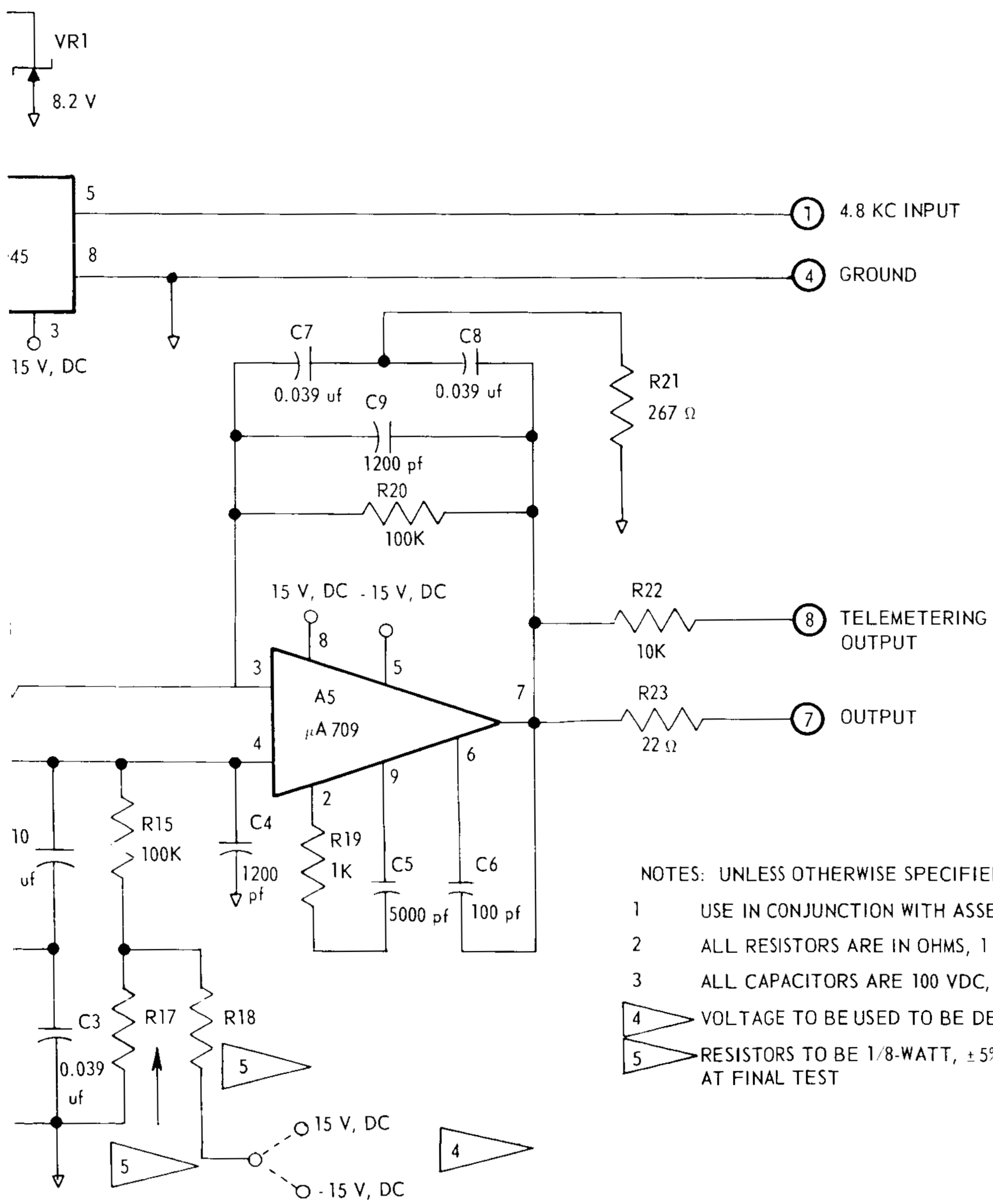
The active filter network provides unity gain for dc, while providing sufficient phase and gain margin to maintain stable closed-loop operation and minimize ringing on the loop transient response. A schematic of this unit is shown in Figure A-3. The voltage transfer function is shown in Figure A-4. For additional information and detailed descriptions of similar devices, refer to GER-12189S6, Interim Report No. 7, prepared on contract NAS 8-20205; GER-11752S3, prepared on task order ASTR-G-GAC-5, contract NAS 8-11270; and GER-11752S2, prepared on task order ASTR-G-GAC-3, contract NAS 8-11270.

The breadboard version of the filter used discrete resistors in the input and feedback networks.

C. PULSE WIDTH MODULATOR - POWER DRIVER

The pulse width modulator and power driver section serves two functions. The pulse width modulator provides pulses on two outputs. Near null or zero volts dc


C11
1 uf
15 V
± 10%
A2
SN354A
R2
250K
R1
49.9K
15 V, DC
C12
1 uf
15 V,DC
± 10%
A3
SN354A
R3
250K
A1
NM1C
15 V, DC
INPUT 3
R4
52.3K
R5
26.1K
INPUT 1
INPUT 2
R6
26.1K
15 V, DC
- 15 V, DC
A4
μ A709
R7
41.2K
R8
1K
C1
1000 pf
C2
20 pf
R9
R10
100K
15 V, DC
- 15 D, DC
R11
41.2K
R12
41.2K
R13
4.75K
R14
4.75K
R16
267 Ω



NOTES: UNLESS OTHERWISE SPECIFIED

1 USE IN CONJUNCTION WITH ASSEMBLY 315N000-025
2 ALL RESISTORS ARE IN OHMS, 1 8-WATT, ± 1%
3 ALL CAPACITORS ARE 100 VDC, ± 5%
4 VOLTAGE TO BE USED TO BE DETERMINED AT FINAL TEST
5 RESISTORS TO BE 1/8-WATT, ±5%, VALUE TO BE DETERMINED AT FINAL TEST

Figure A-1. Preamplifier Demodulator Schematic

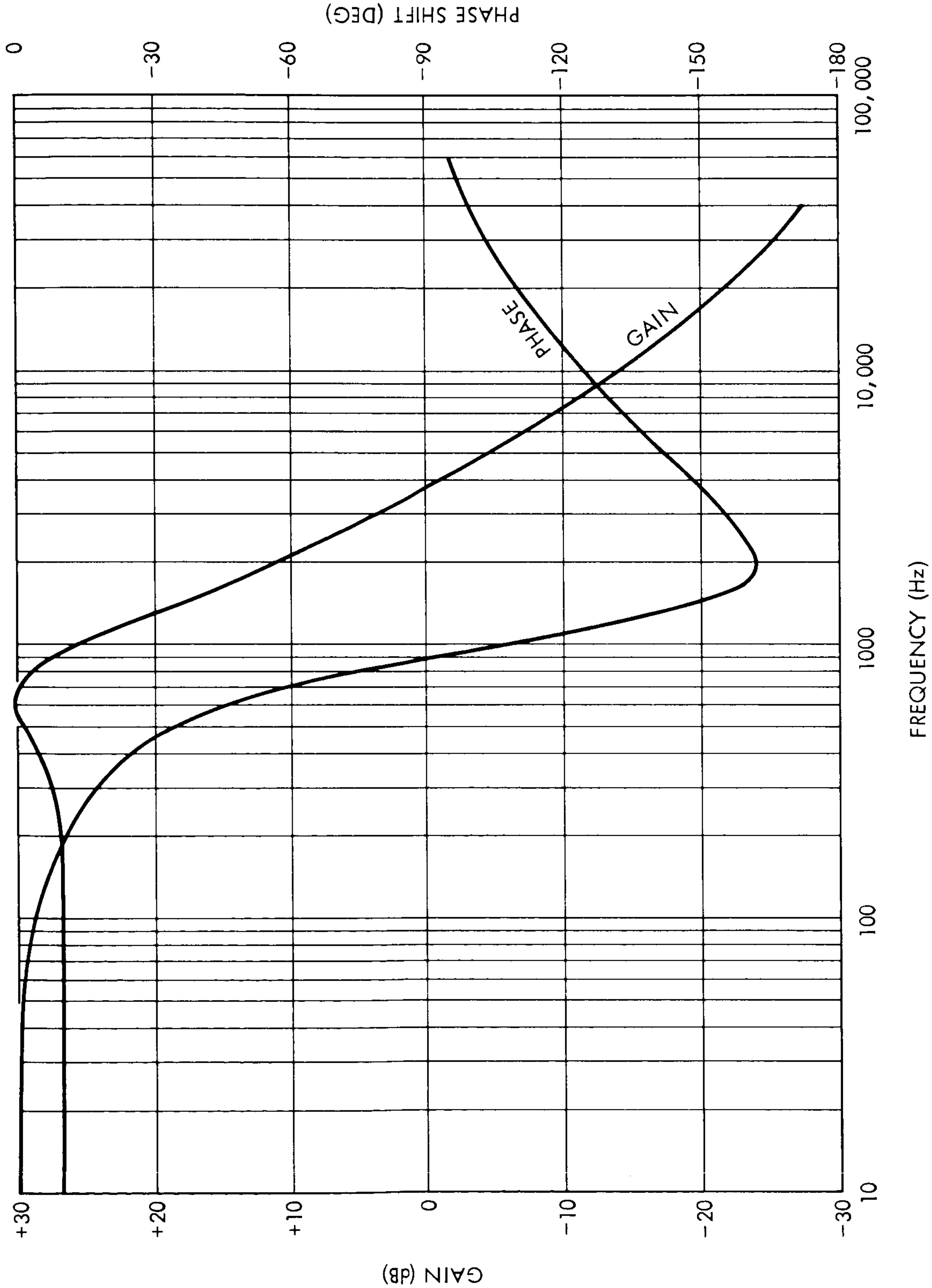


Figure A-2. Voltage Transfer Characteristic of Preamplifier Demodulator

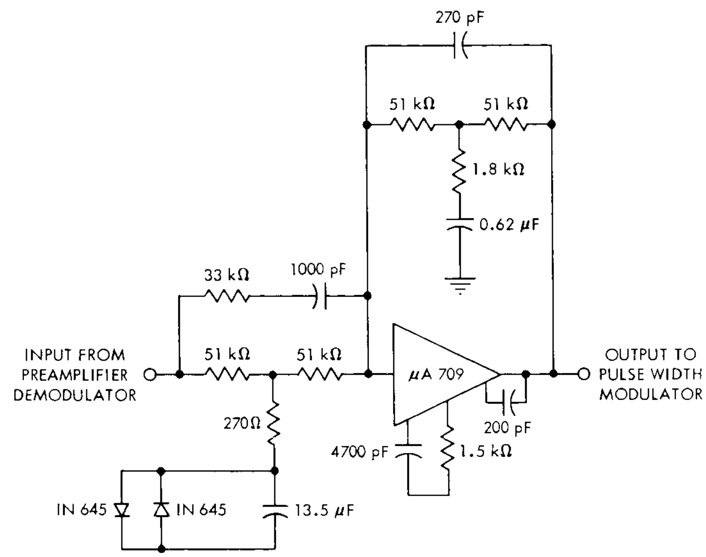


Figure A-3. Active Filter (Lead Network)

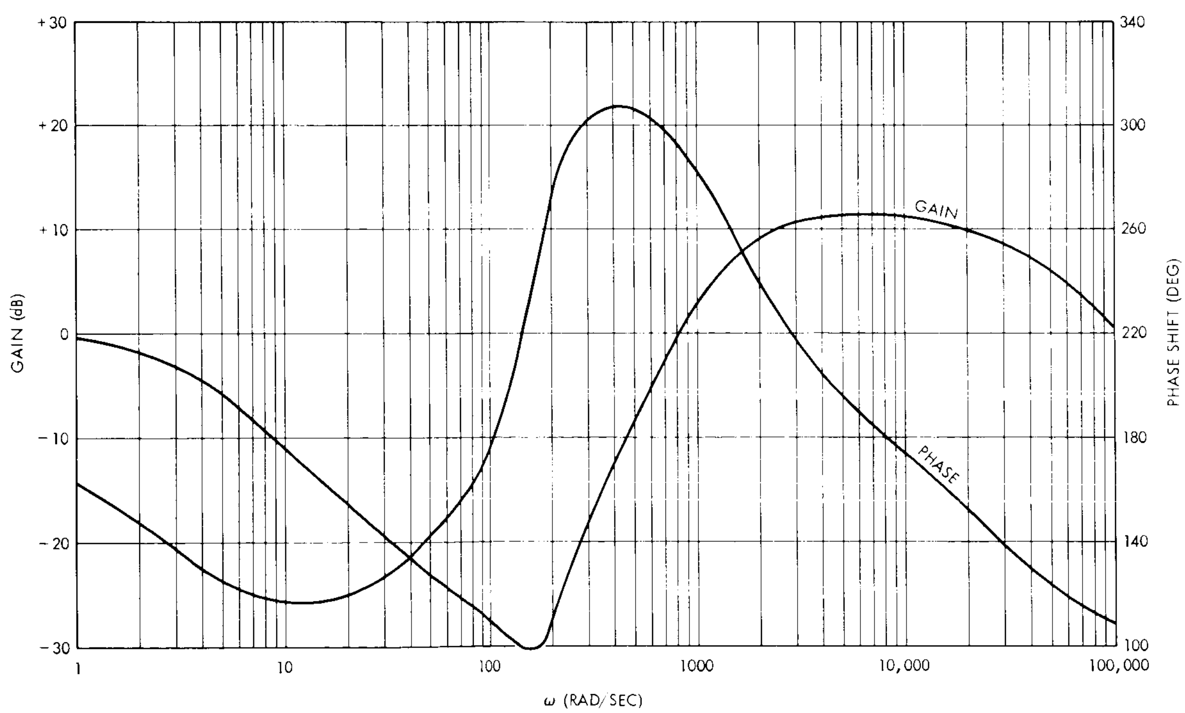


Figure A-4. Voltage Gain and Phase for Active Filter (Lead Network) input pulses appear on both output leads. As a small positive d-c voltage is applied, pulses on one output lead increase in width, while the pulses on the other lead diminish in width and disappear at some small, fixed, d-c input level. As the d-c level is increased in the positive direction, the pulses on the one output lead increase in pulse width, while no pulses appear on the other lead. As negative dc is applied to the input, the same action takes place on opposite output leads. For proper operation in this application the pulse width modulator requires the generation of a 4.8 kHz triangular wave, which is generated by the use of a squaring circuit and an integrating network. The squaring circuit is driven from the 10 Vrms sine wave signal used for the preamplifier demodulator reference. A schematic of the pulse width modulator and triangle wave generator is shown in Figure A-5.

The power driver converts the two outputs from the pulse width modulator into bipolar voltage pulses to the d-c torquer, which is used to drive the servo loop back to a null state. The power driver is capable of supplying up to 50 watts of power, or approximately 2 amperes, to the 28V torquer. A schematic of the power driver portion of the circuit is given in Figure A-6.

When connected as a composite assembly, the pulse width modulator and power driver could be described as metering current or voltage to the load, dependent on the d-c input level to the pulse width modulator. The transfer characteristic of current to load versus d-c input voltage is shown in Figure A-7.

For more information regarding the pulse width modulator and power driver combination, see Interim Report No. 9, GER-12189S8 prepared on this contract; GER-11752S4 prepared on contract NAS 8-11270, task order ASTR-G-GAC-6; and GER-11752S6, prepared on task order ASTR-G-GAC-9, contract NAS 8-11270.

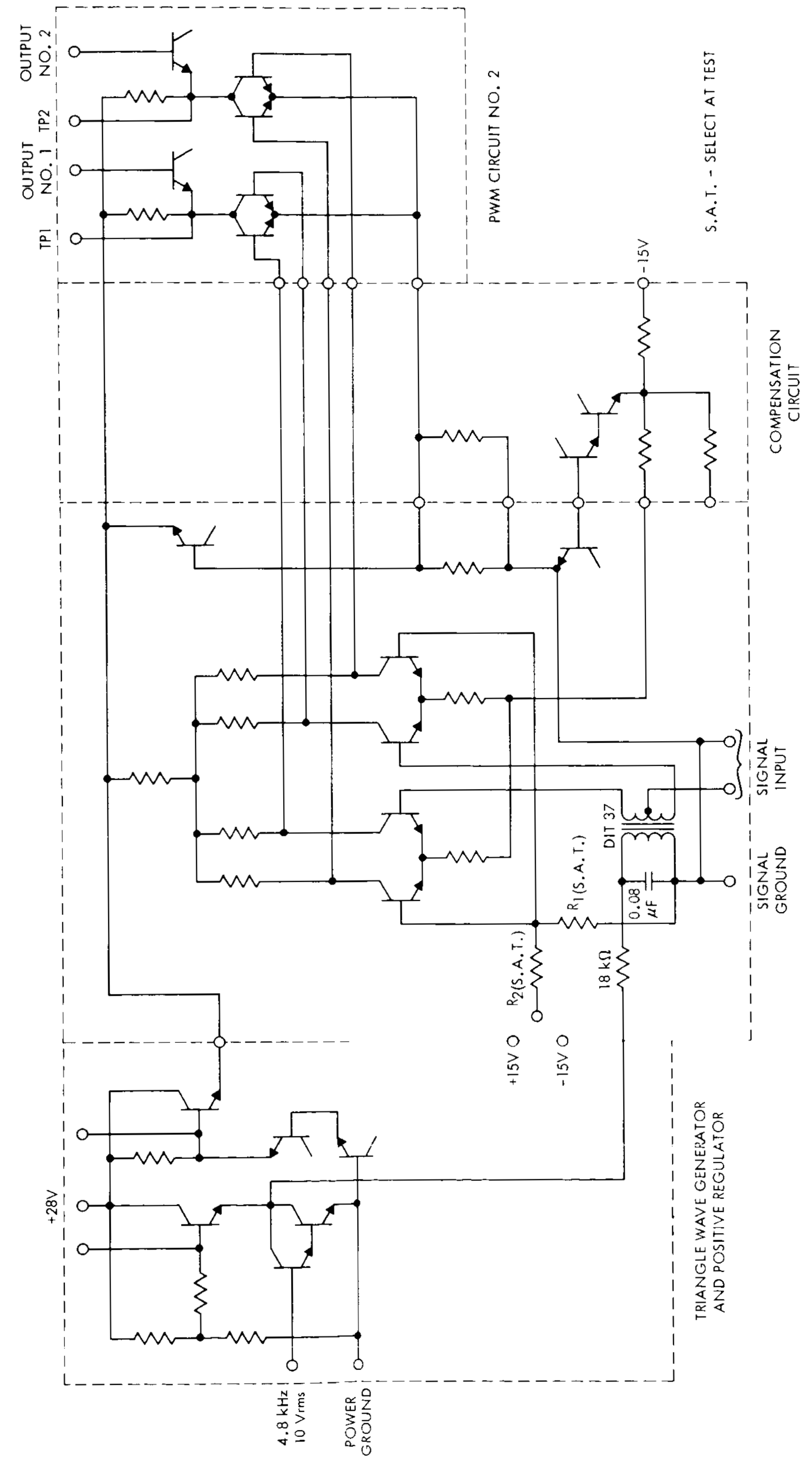


Figure A-5. Pulse Width Modulator and Triangle Wave Generator

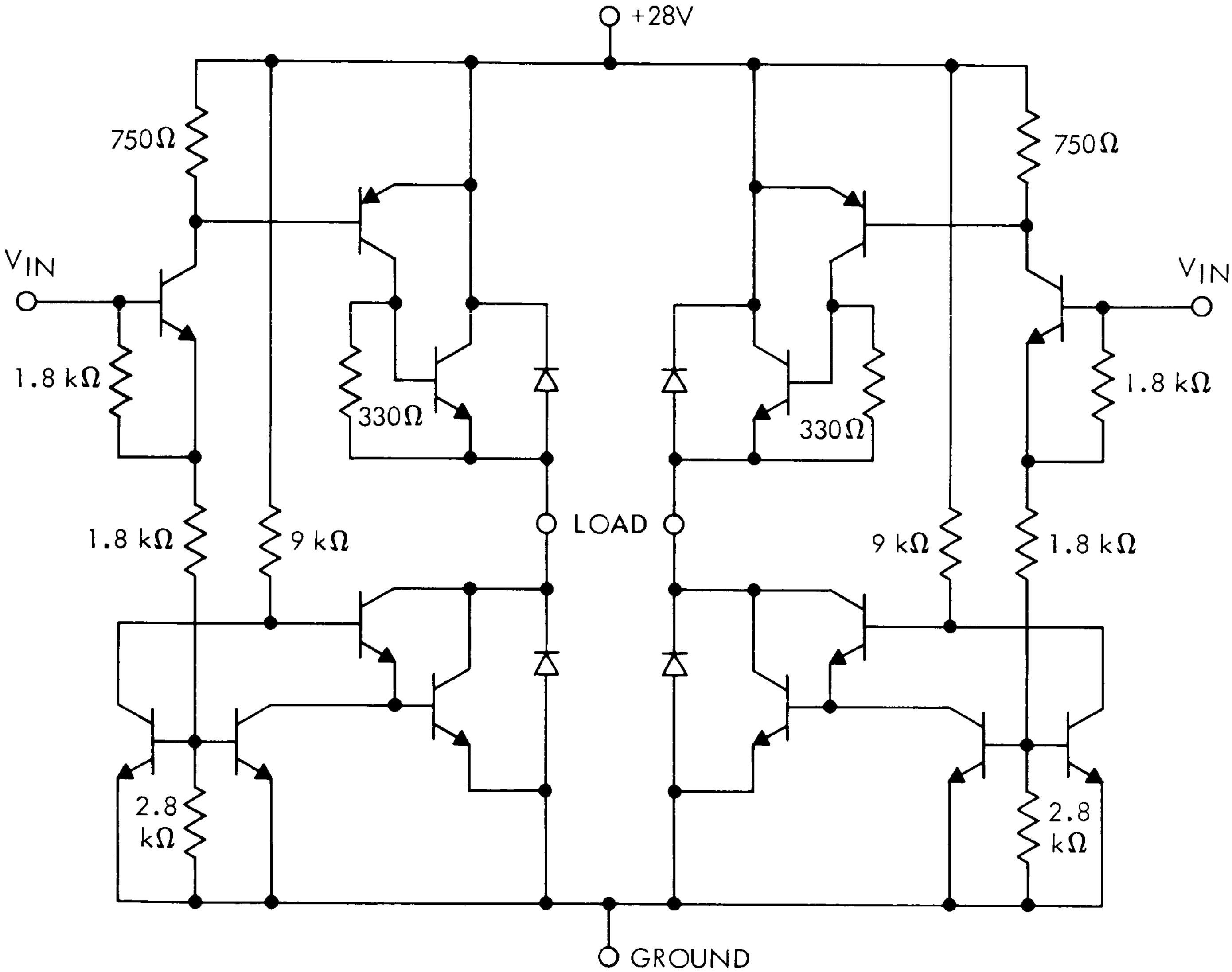


Figure A-6. Power Drive Circuitry

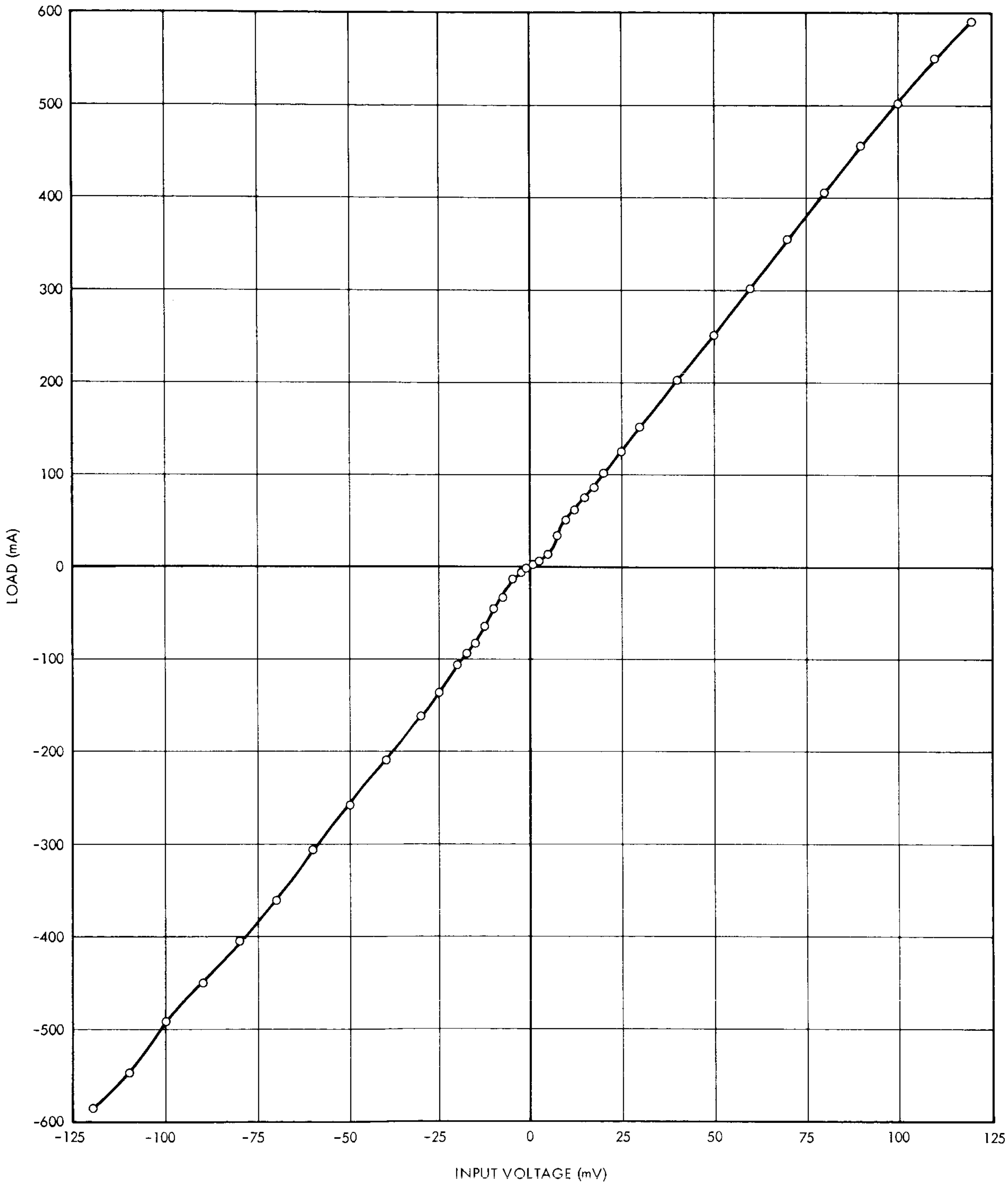


Figure A-7. Power Driver

D. POSITIVE AND NEGATIVE POWER SUPPLY

Power for the electronics, other than the 28 VDC (±4V), is supplied from the positive and negative power supply and regulator. Several regulated voltages are supplied as +15 VDC and -15 VDC. Both the plus and minus 15V supplies are regulated and capable of supplying in excess of 30 mA. The minus supply is generated by chopping the 28 VDC into a 4.8 kHz square wave, a-c coupling this chopped wave into a negative half-wave rectifier, and regulating the output to -15V. The positive 15V regulated supply is obtained by using standard zener regulating techniques. A schematic of the power supply and regulators is shown in Figure A-8.

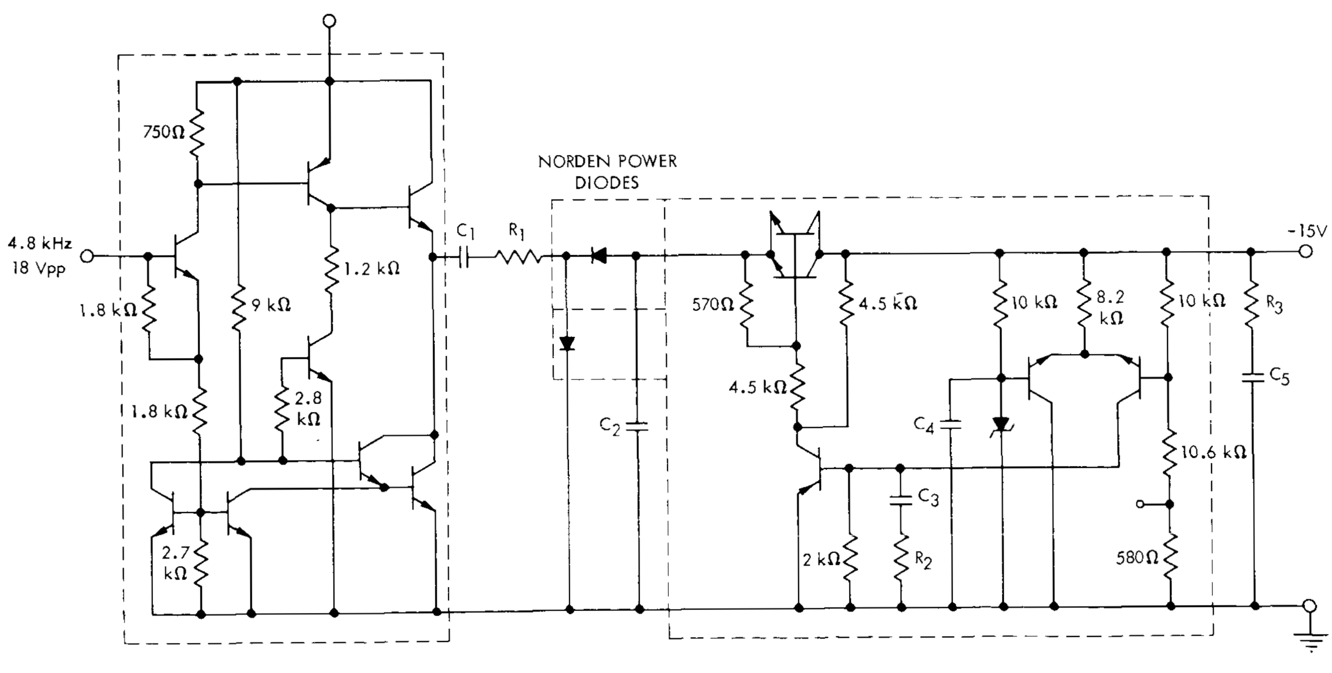


Figure A-8. Positive and Negative Power Supply